

# Efficient Groundwater Treatment Using the BIOTTTA™ System

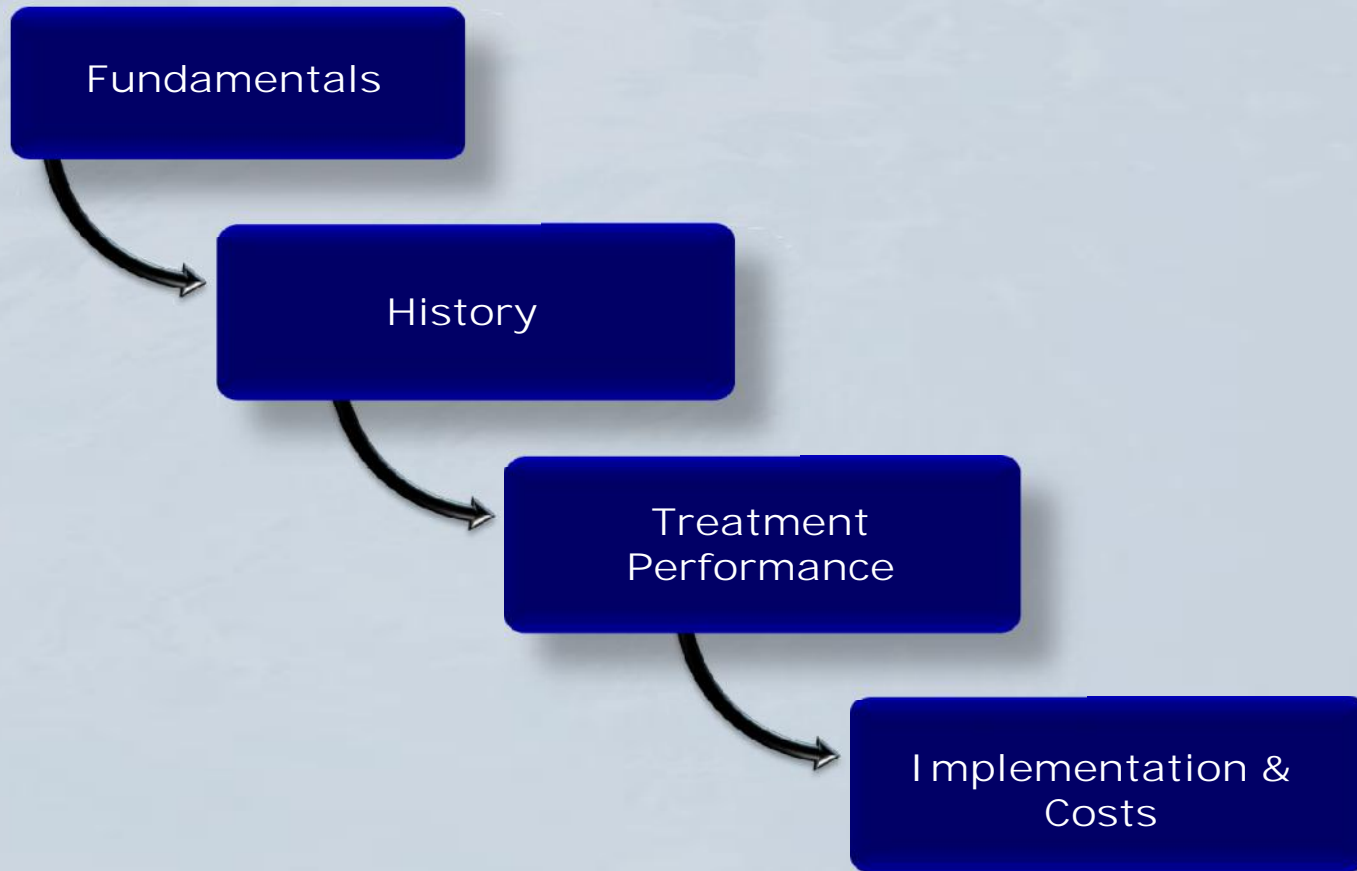


Jess Brown

Chris Cleveland

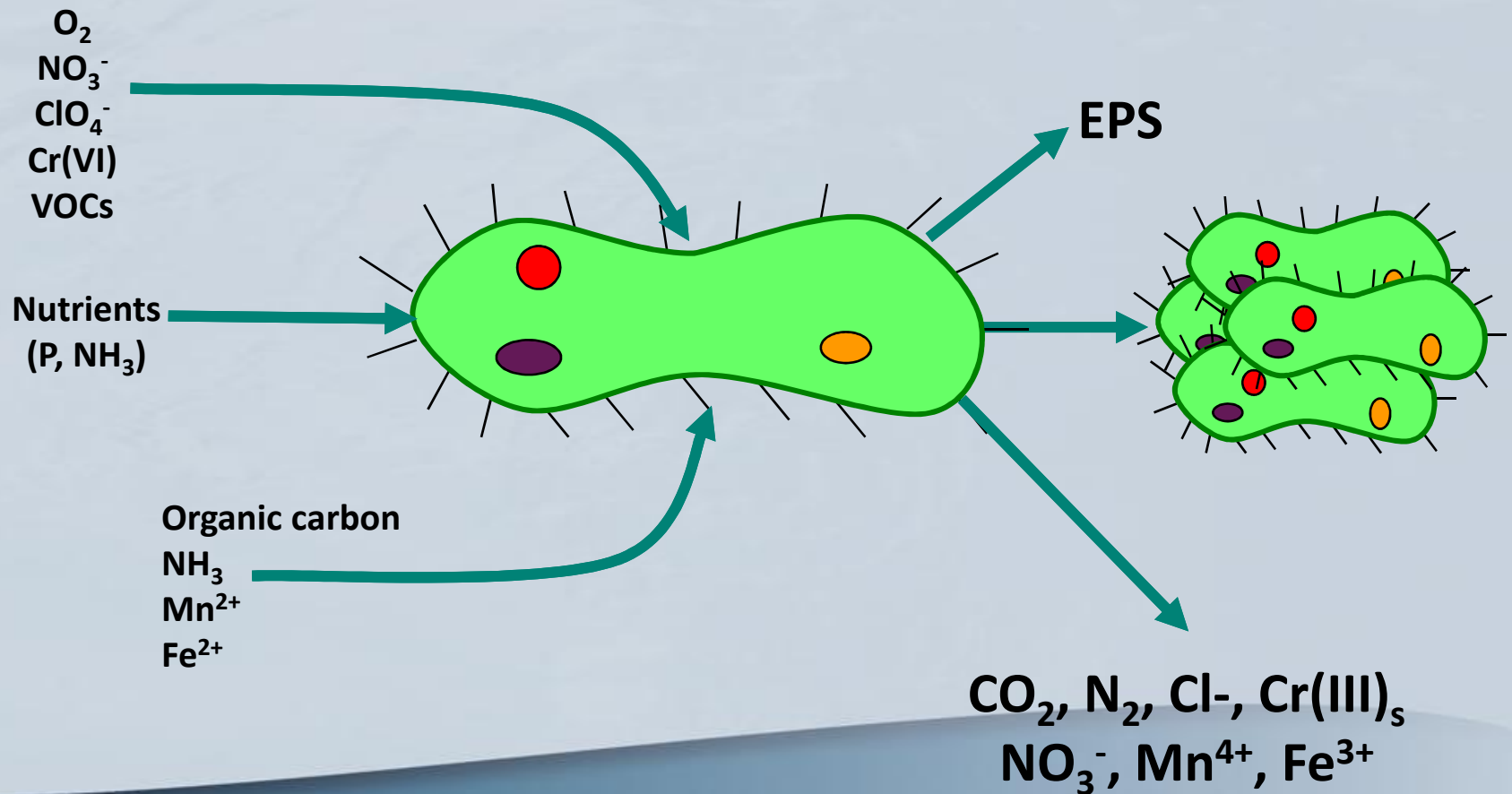
  
*Engineers...Working Wonders With Water™*

# This presentation discusses...

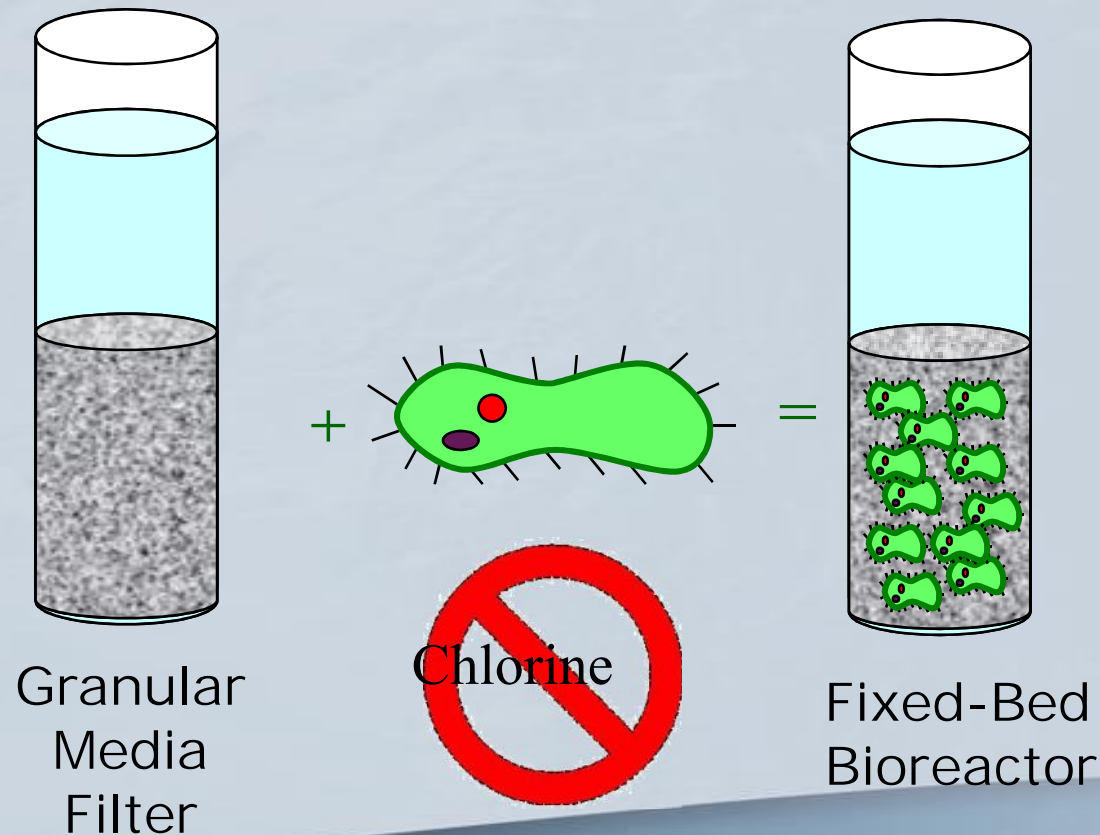


# Fundamentals

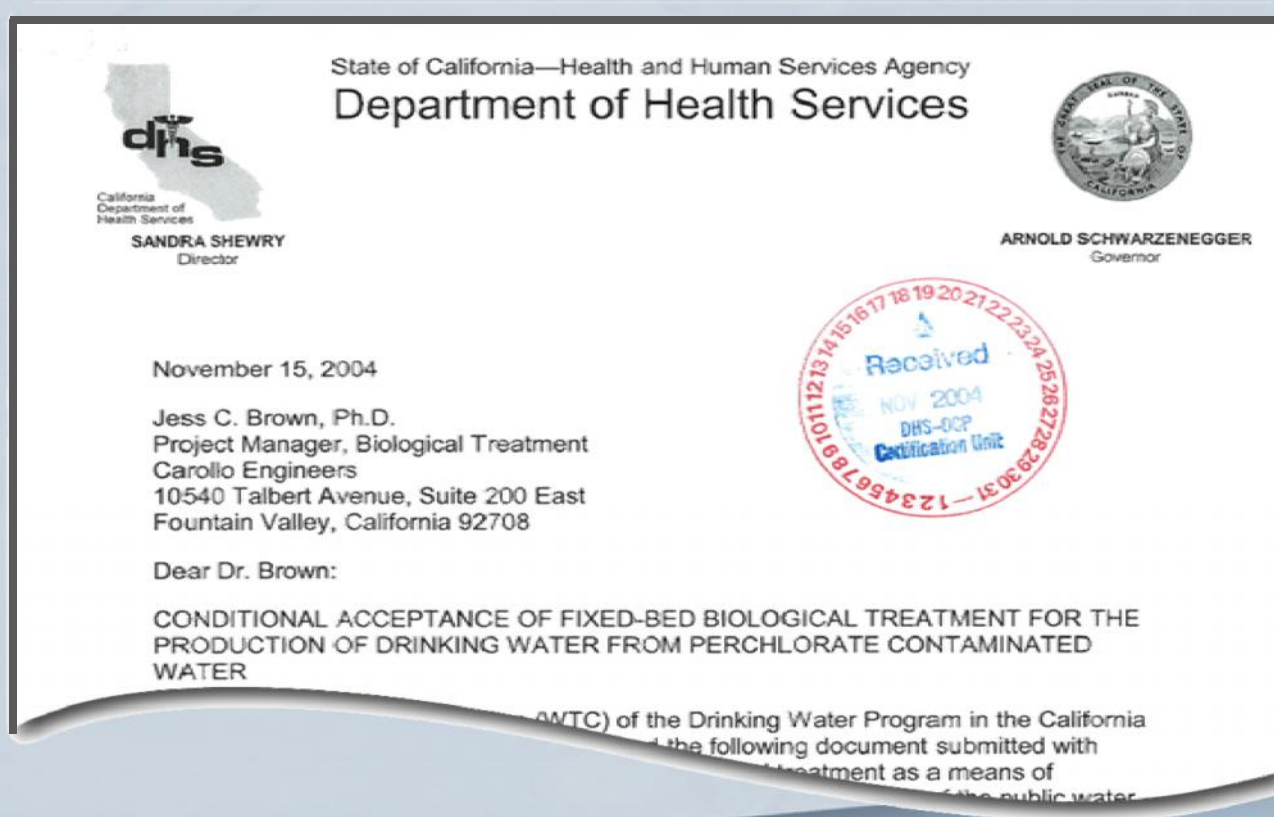
# Bacteria Oxidize and Reduce Contaminants to Generate Energy and Grow



# Fixed-Bed Biological Treatment is Modified Conventional Granular Media Filtration



# Fixed-Bed Biological Treatment Achieved CDPH Conditional Approval in 2004

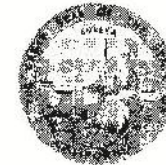


# Updated Approval Letter in 2011 added Nitrate and Specified Post-Treatment Requirements



MARK B HORTON, MD, MSPH  
*Director*

State of California—Health and Human Services Agency  
California Department of Public Health



EDMUND G. BROWN JR.  
*Governor*

January 13, 2011

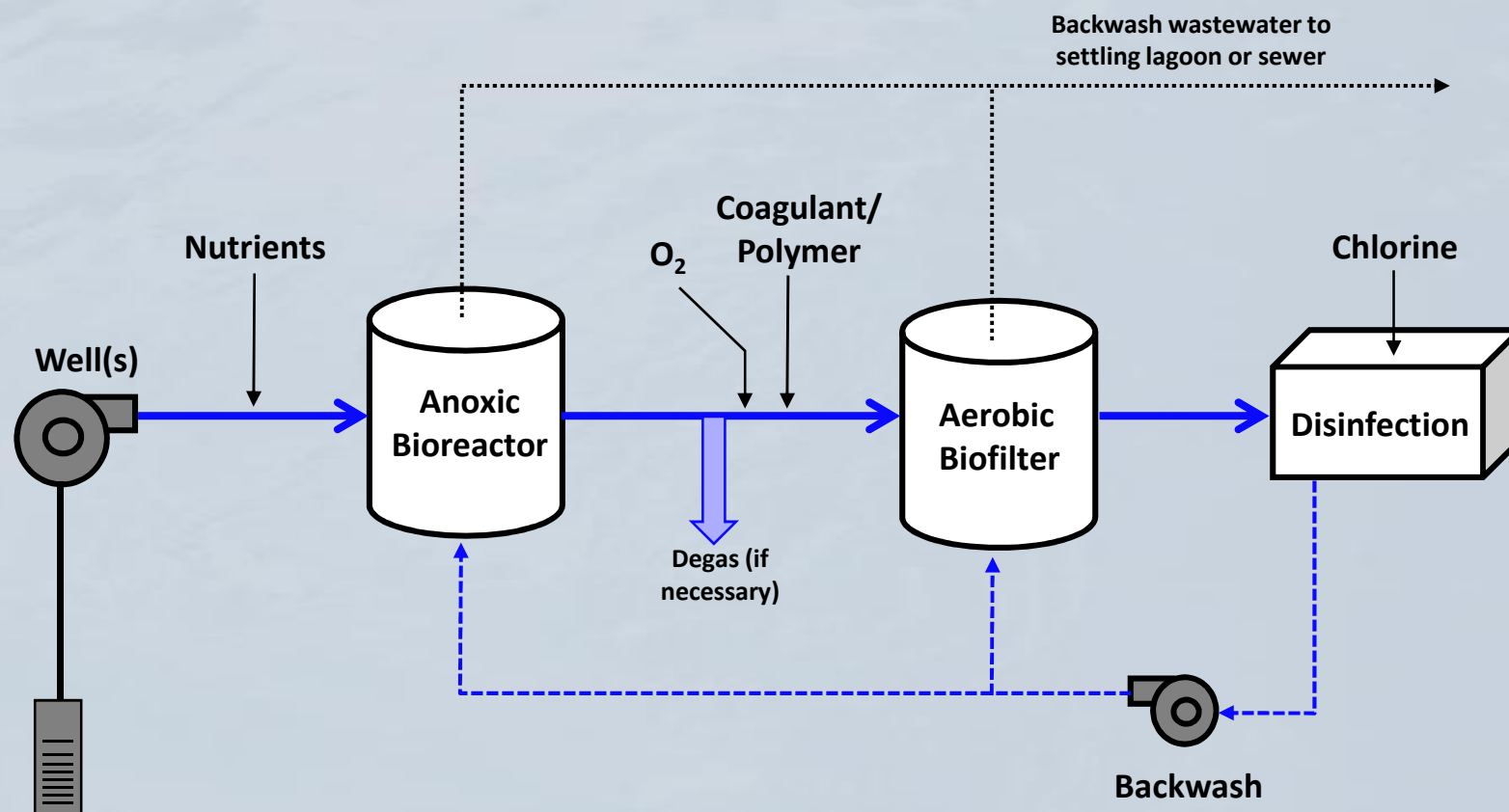
Jess C. Brown, Ph.D.  
Project Manager, Biological Treatment  
Carollo Engineers  
10540 Talbert Ave, Suite 200  
Fountain Valley, CA 92708

Dear Dr. Brown:

ADDEMDUM TO CONDITIONAL ACCEPTANCE OF FIXED-BED BIOLOGICAL  
TREATMENT FOR THE PRODUCTION OF DRINKING WATER FROM  
PERCHLORATE CONTAMINATED WATER

"The study results indicate that a properly designed and operated fixed bed biological treatment can be used as one of the unit processes for the reduction of perchlorate and nitrate from water sources"

# Biologically-Tailored, Two-Stage Treatment Approach: Meets Regulatory Requirements and Incorporates 15 Years of Process/Design Optimization



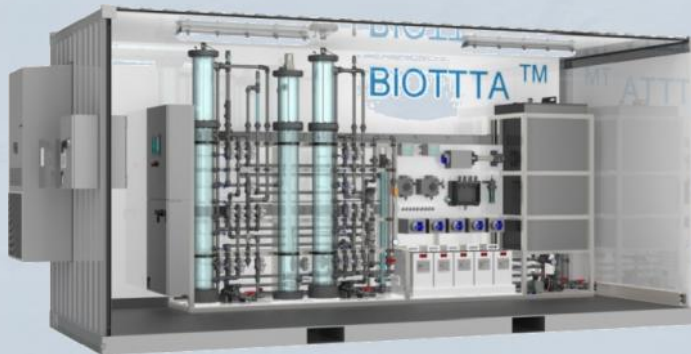
BIOTTTA™



# 3 BIOTTTA™ Pilots Range from 0.4-25 gpm



10-25 gpm



0.4-2 gpm

2-6 gpm

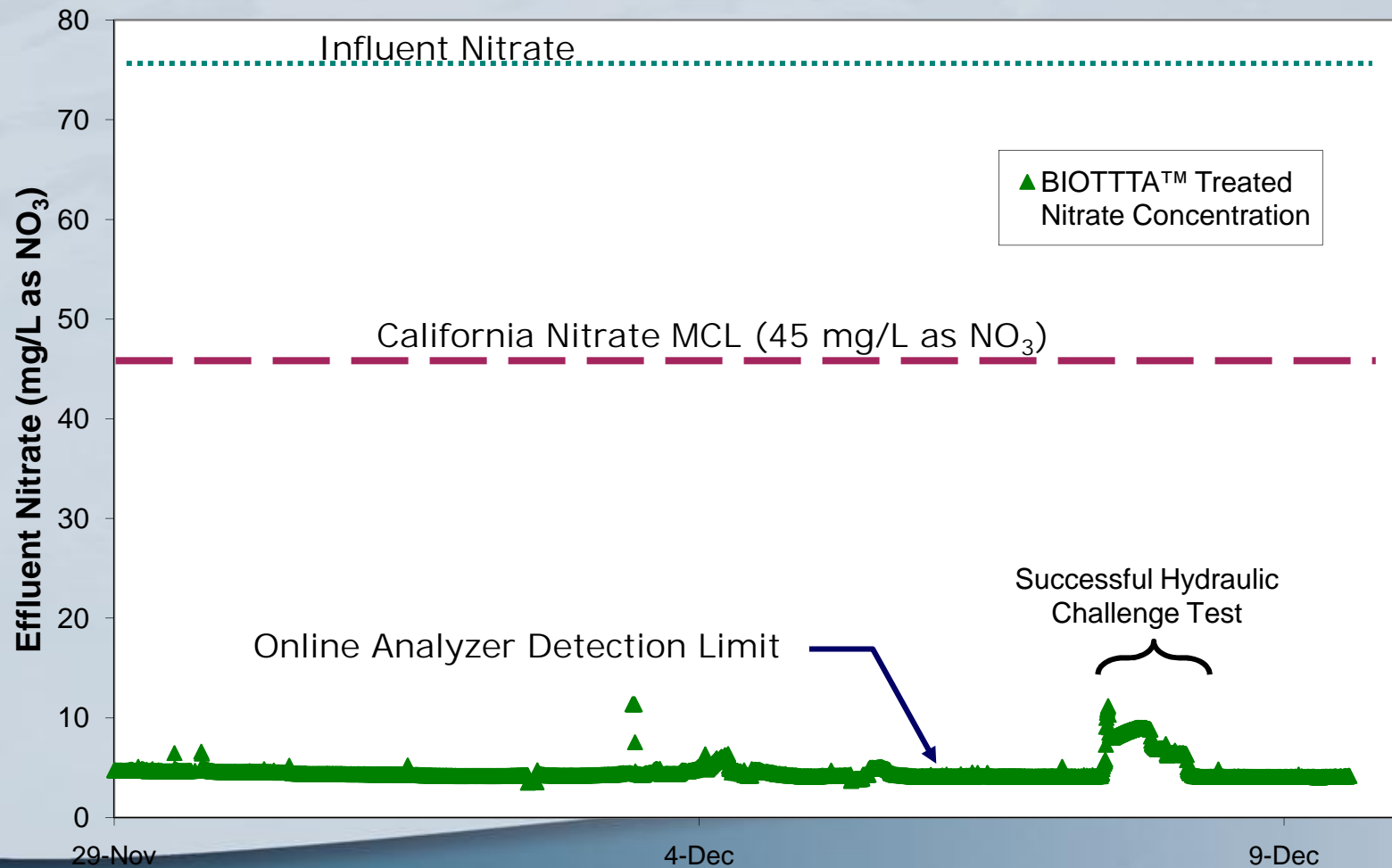


# History of BIOTTTA™ Optimization & Demonstration

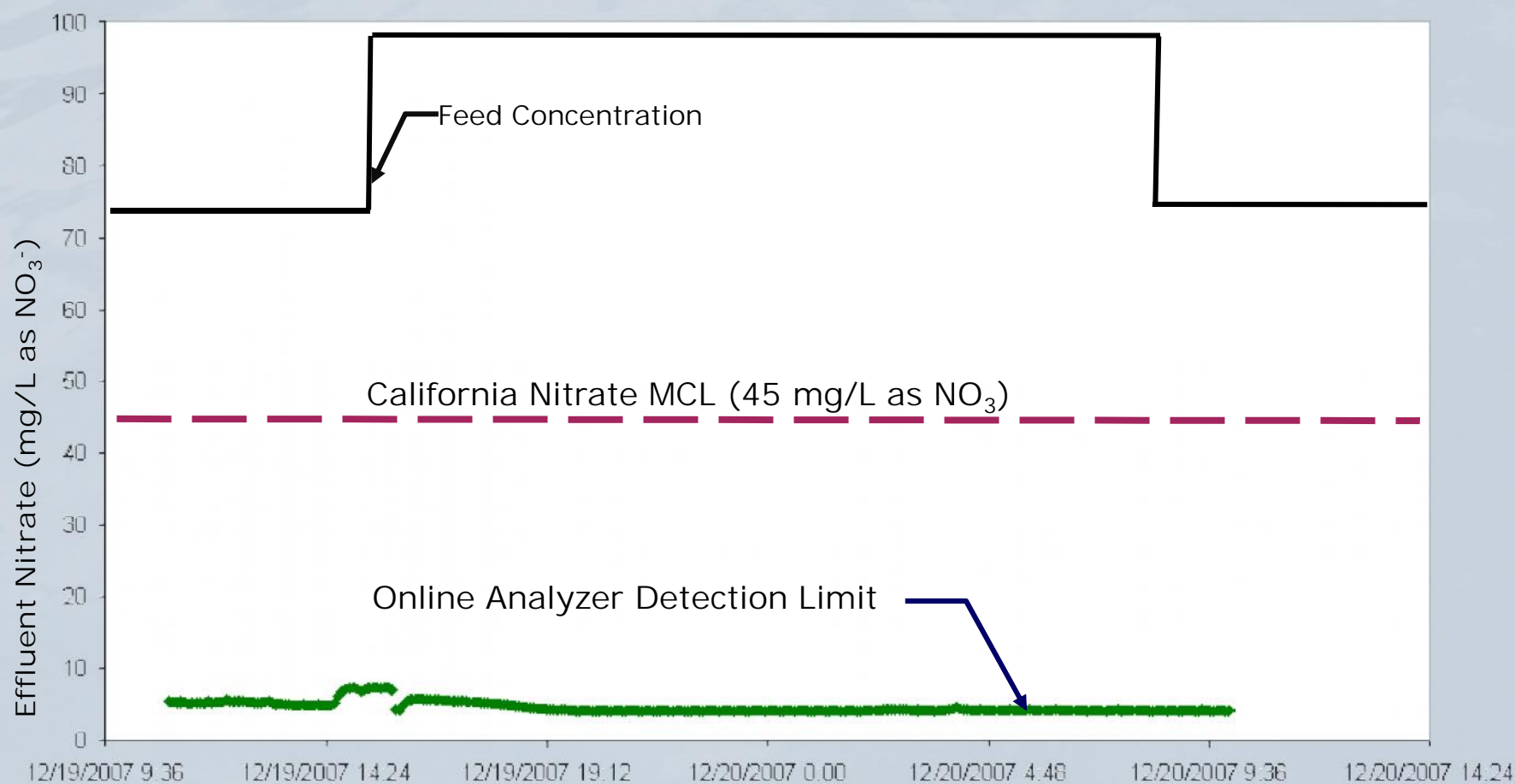
1. Bench-scale testing: 1998-2002
2. Pilot-scale optimization 2002-present
  - a. Castaic Lake Water Agency ( $\text{ClO}_4^-$ ,  $\text{NO}_3^-$ )
  - b. Western Municipal Water District ( $\text{NO}_3^-$ ,  $\text{ClO}_4^-$ , DBCP)
  - c. Dept of Defense/Rialto ( $\text{ClO}_4^-$ ,  $\text{NO}_3^-$ )
  - d. Lincoln Pipestone Rural Water ( $\text{NO}_3^-$ , Mn)
  - e. CDA ( $\text{NO}_3^-$ , TCE, TCP)
  - f. Additional Southern CA Utility – Contract Pending ( $\text{NO}_3^-$ , DBCP,  $\text{Cr}^{6+}$ )
3. Full-scale installations: none
  - a. Construction on LPRW system anticipated in 2014 (~400-gpm system)
  - b. DOD funding in place for 2,000-gpm installation in parallel with FBR at WVWD

# **BIOTTTA™ Treatment Performance**

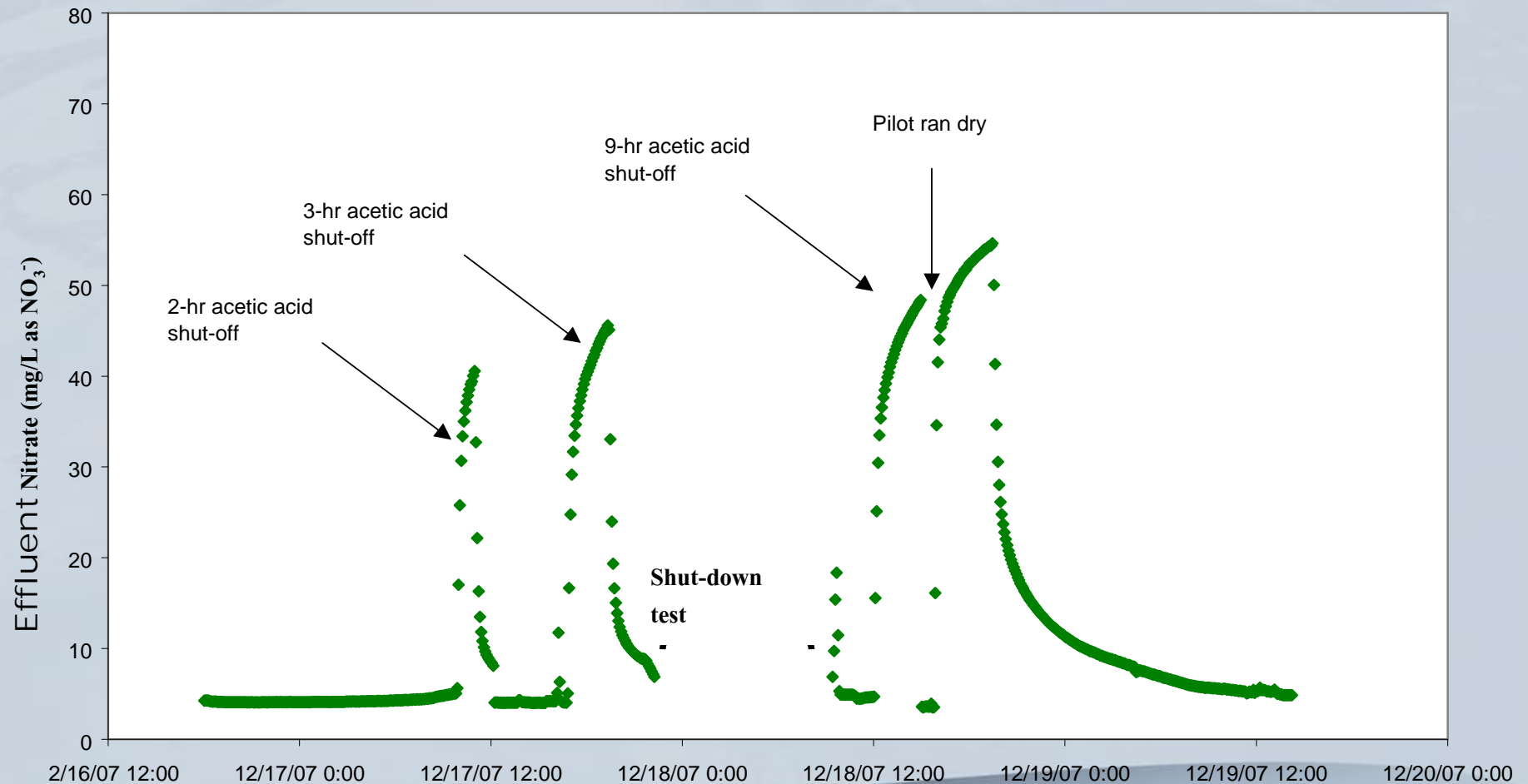
# Sustained Nitrate Removal Achieved at EBCTs as Low as 4 Minutes



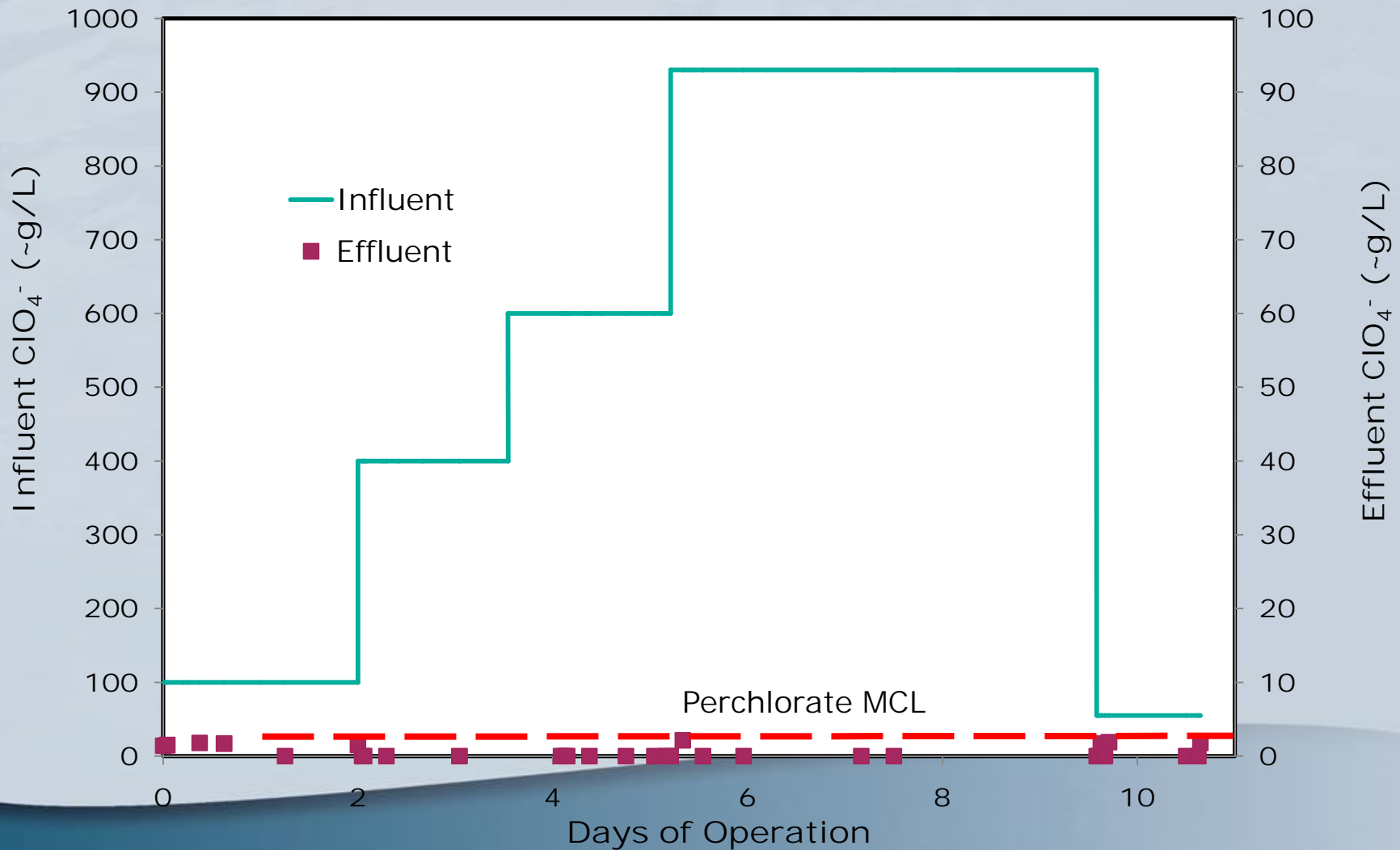
# BIOTTTA™ is Robust with Respect to Fluctuations in Raw Water Nitrate Concentration



# Rapid Nitrate Removal Performance Recovery Observed During Acetic Acid Shut-Down Tests

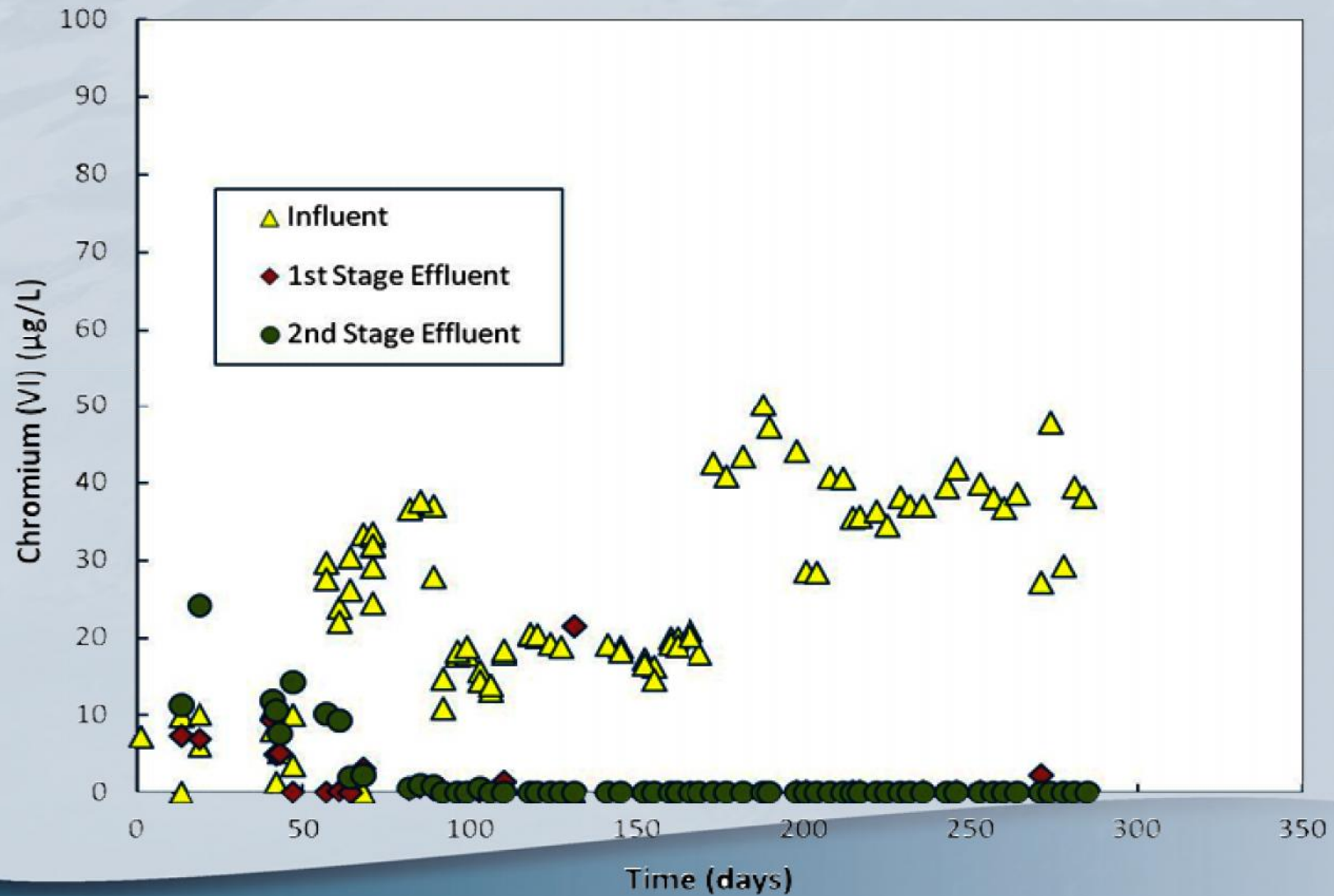


# Perchlorate Removal Performance Is Independent of Raw Perchlorate Concentration



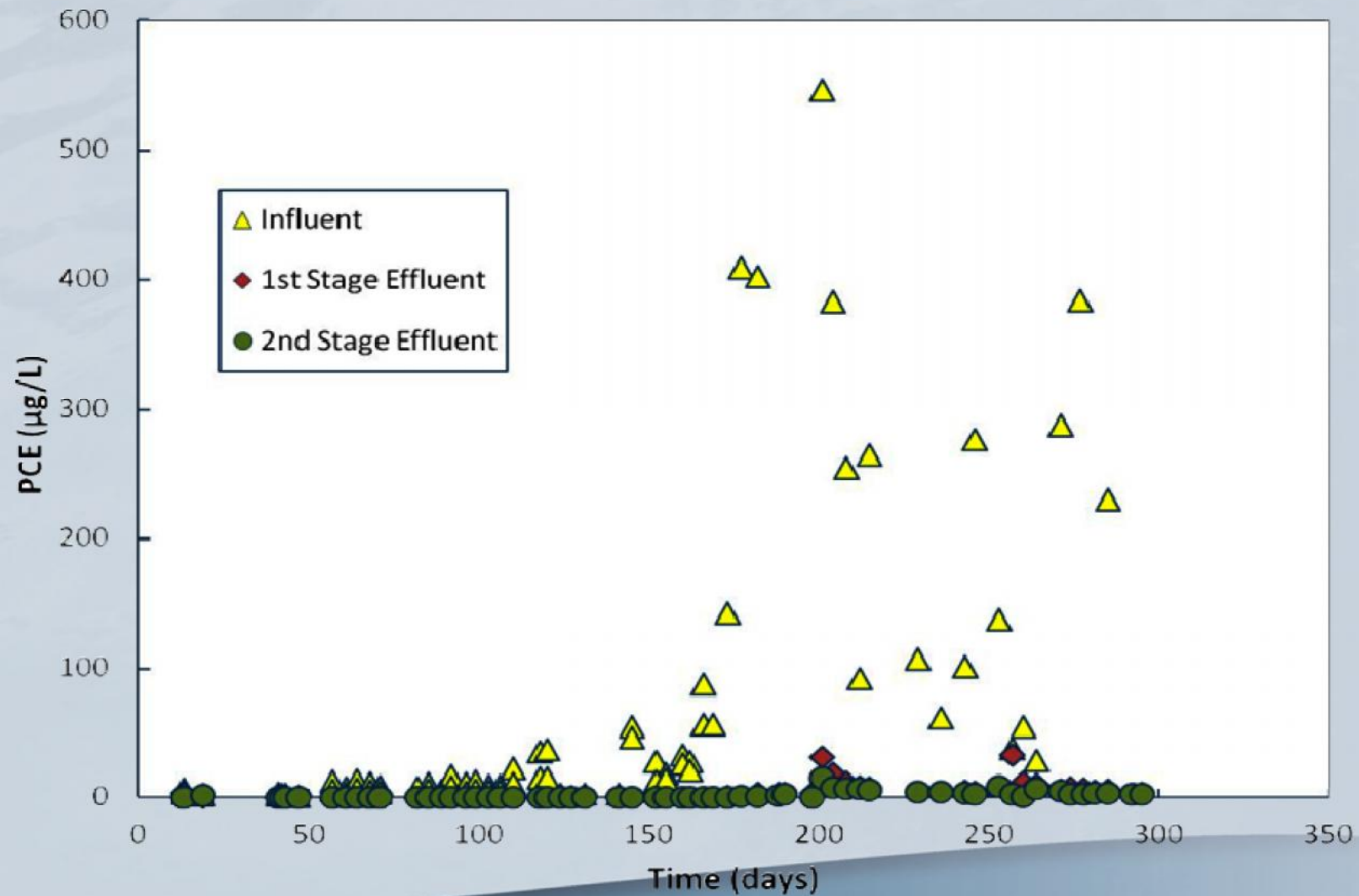


# Efficient Chromium 6 Removal Observed

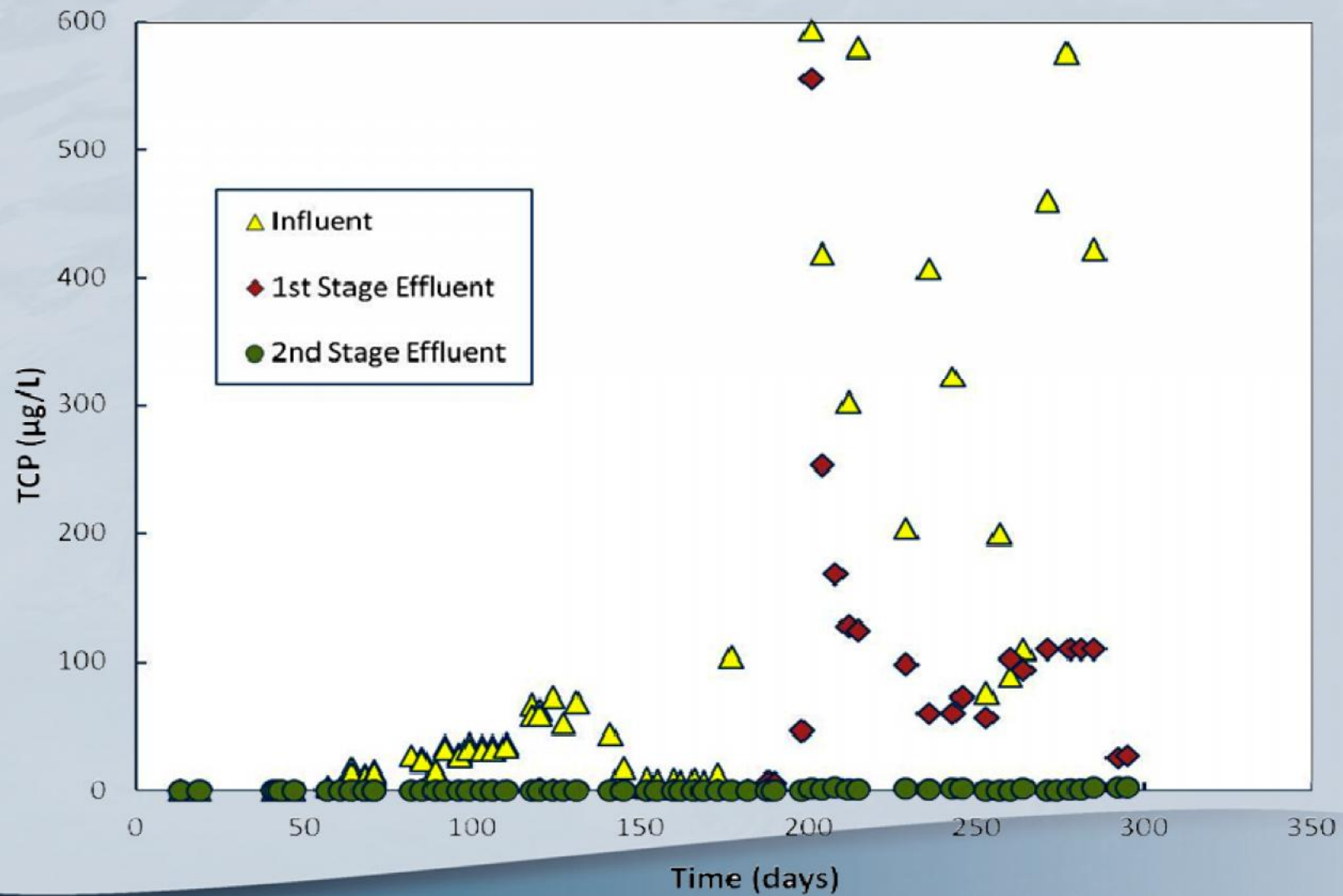




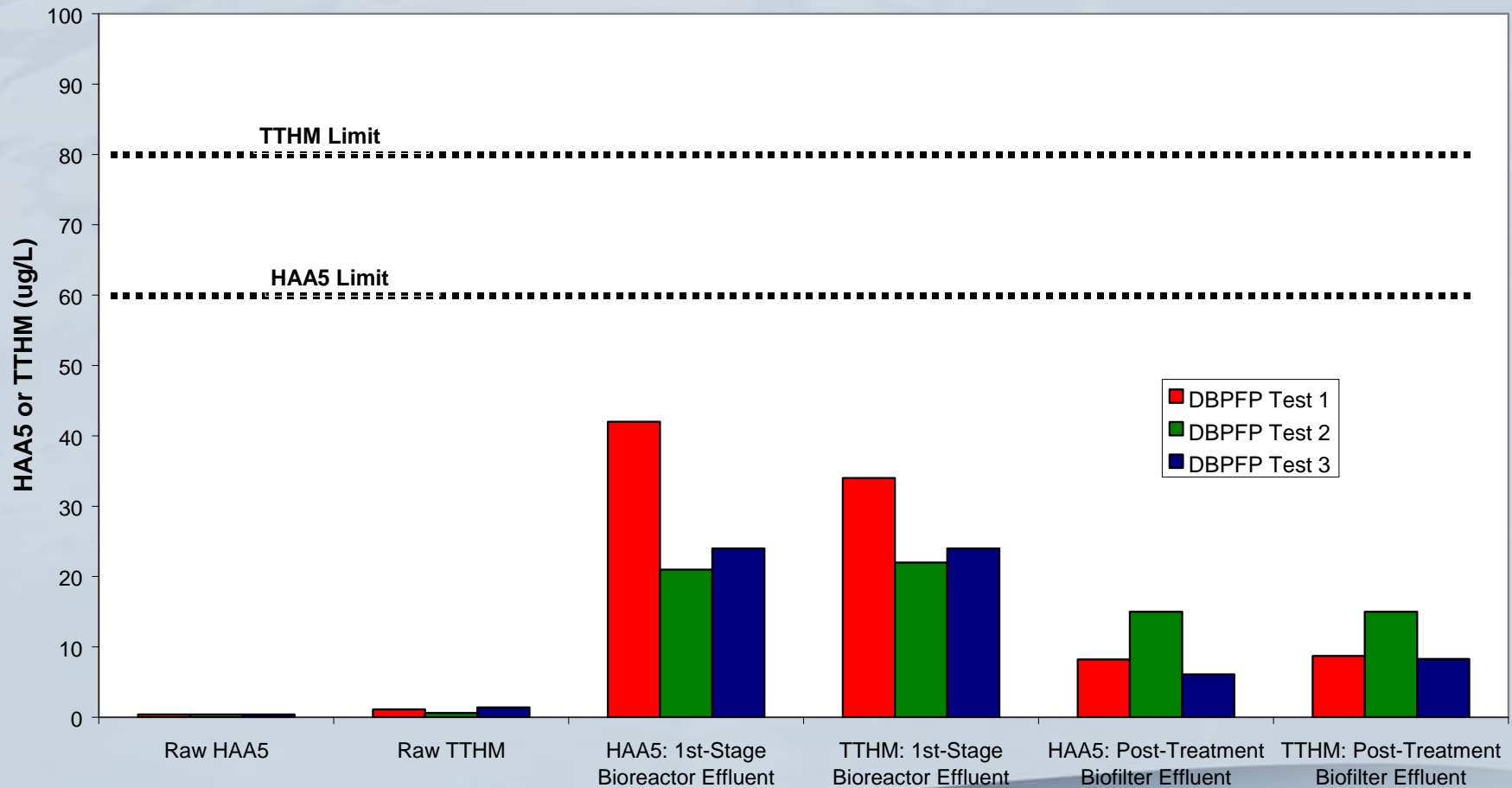
# Efficient PCE Removal Observed



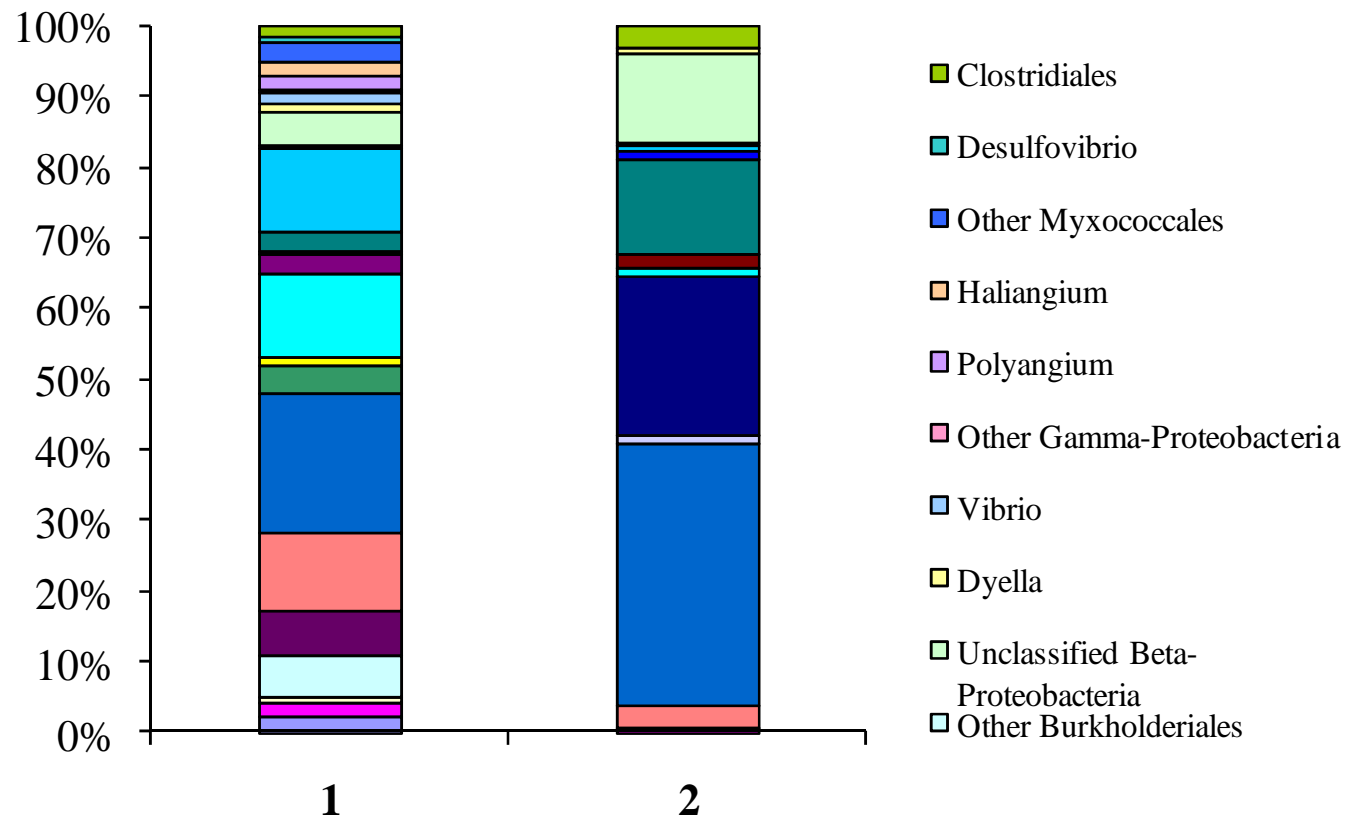
# Efficient TCP Removal Observed



# BIOTTTA™ Effluent Has Low DBP Formation Potential



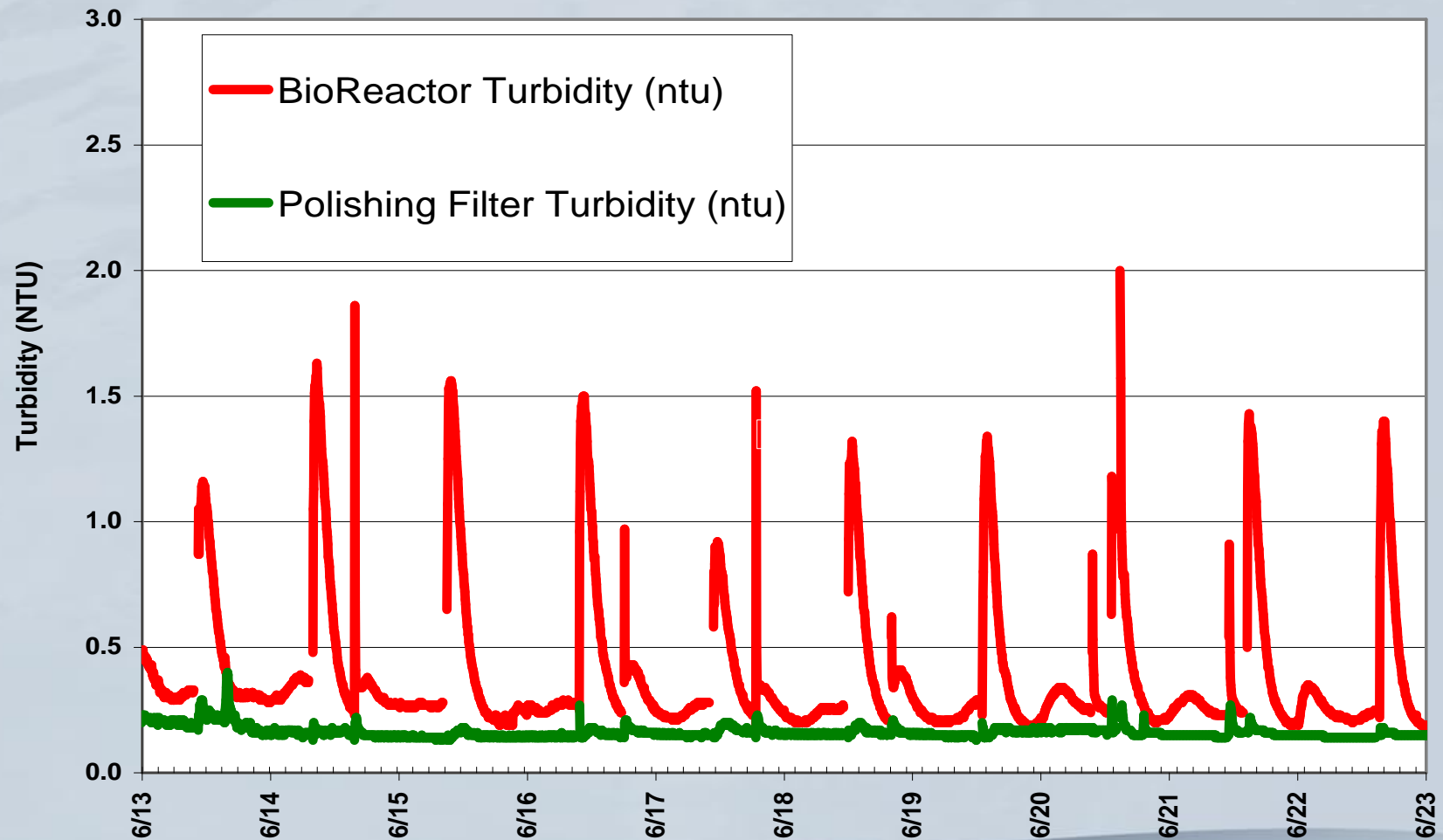
# Relative abundance



## **...Making the Effluent of these Systems Highly Vulnerable to Chlorination**

1. Gram-negative bacteria have thin cell walls
2. Free chlorine CTs of 2 mg-min/L decreased HPCs from “too-numerous-to-count” (>5,700 CFU/mL) down to <100 CFU/mL

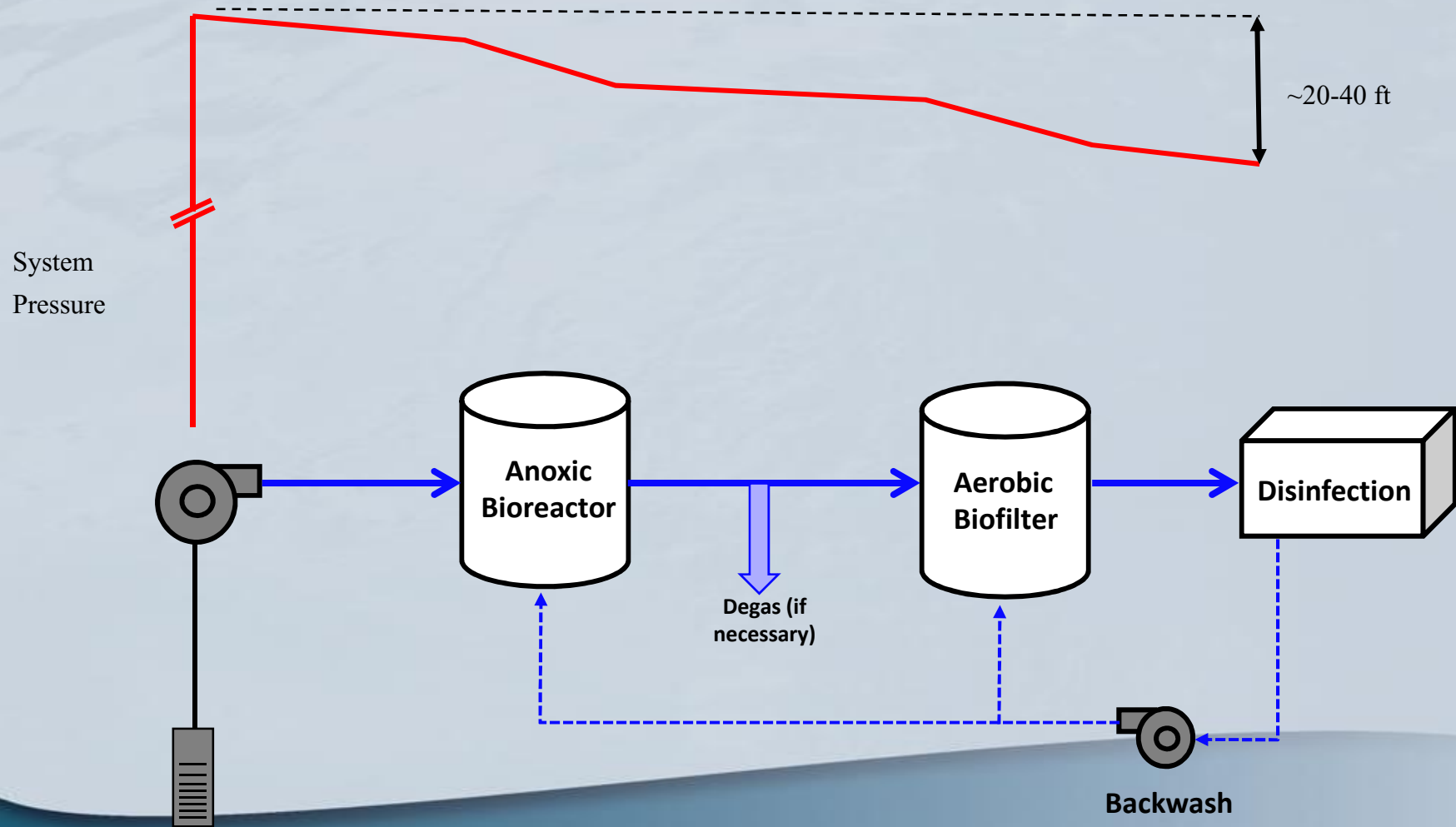
# Two-Stage System Achieves Low Turbidities



# Biotreatment Avoids the Production of High-Strength Waste

1. Recoveries are typically 96%
2. Additional backwash wastewater solids settling can increase recovery
3. Backwash wastewater composition
  - a. 200-300 mg/L VSS/TSS
  - b. 200-300 mg/L COD
  - c. No nitrate unless backwashing with raw water

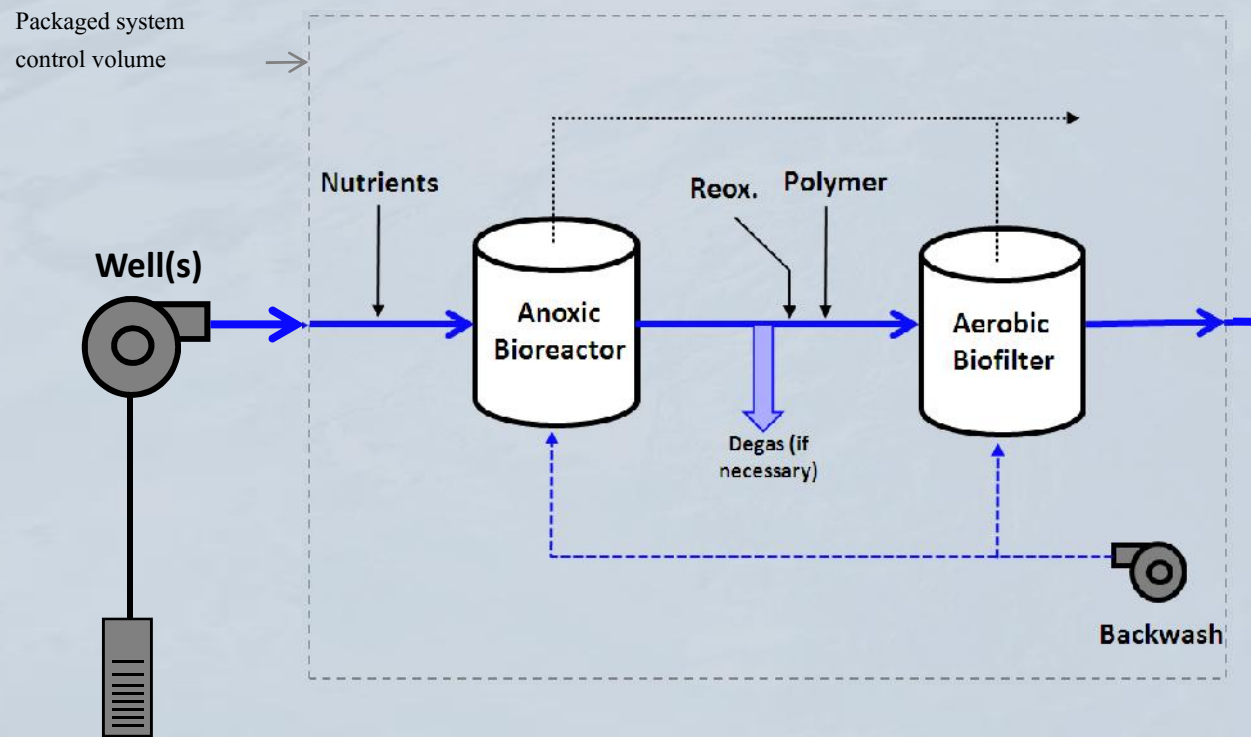
# Low Headloss = Low Energy





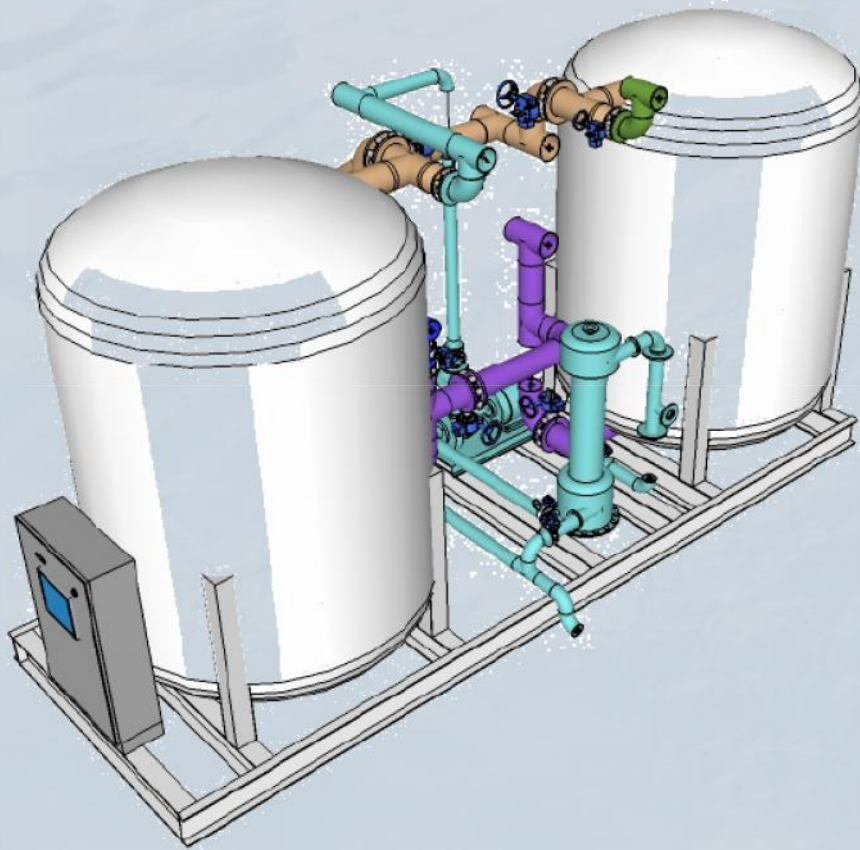
# **Implementation and Costs**

# BIOTTTA™ Is a Complete Packaged Treatment System



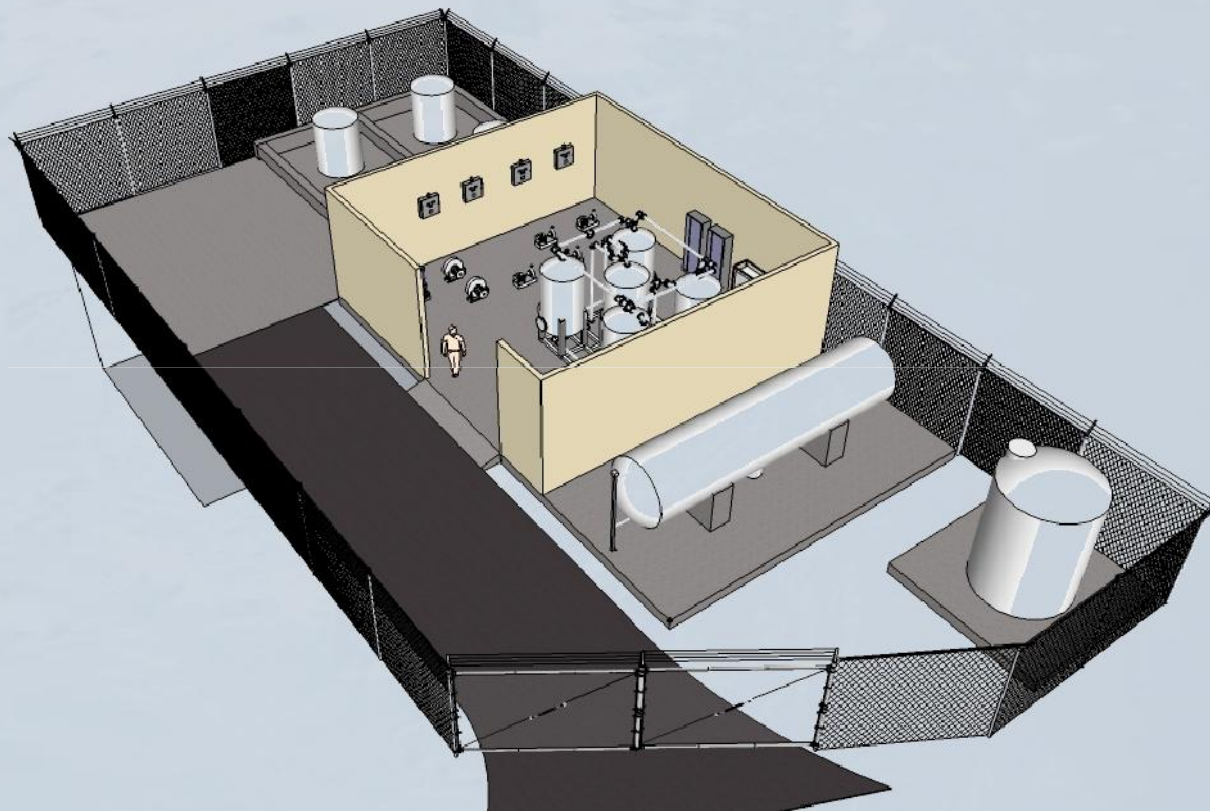
- Simple to Operate
- Integrated Controls
- Compact Footprint
- Robust Operation
- Scalable
- Flexible

# BIOTTTA™ Is Modular...



- Standardized systems
- Skid mounted
- Patent pending control system
- Remote monitoring, alarming, and control available

## ...Simplifying Sizing Per Site



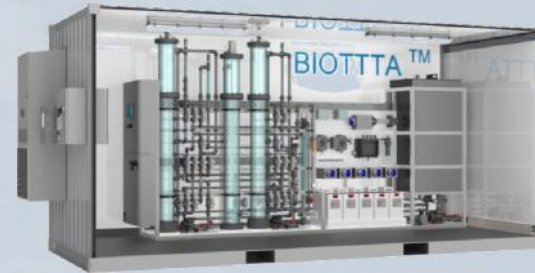
# BIOTTTA™ Provides Comprehensive Solution



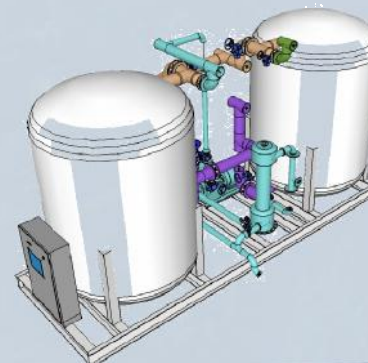
Contaminant  
Characterization



WTP Design/  
Construction



Pilot Study



System  
Fabrication

# What Drives Costs?

1. System capacity, but capital costs largely independent of water quality and treatment goals
2. O&M costs driven by water quality
  - a. Target nitrate removal
  - b. Unit cost of acetic acid

## 50-gpm Treatment System @ 24/7 Operation

1. One 2-stage skid with 4'-diameter pressure vessels
2. Includes system controls, in-line analyzers, backwash system
3. Raw water  $\text{NO}_3^- = 60 \text{ mg/L}$ ; treated water  $\text{NO}_3^- = 30 \text{ mg/L}$



# Cost Model Facilitates Rapid Feasibility Analysis

**BIOTTTA™**  
Packaged Nitrate/Perchlorate Removal Systems by  
**carollo**  
Engineers, Operating Monitors With Water-1

CLIENT: \_\_\_\_\_  
PROJECT: \_\_\_\_\_  
JOB #: \_\_\_\_\_  
BY: \_\_\_\_\_  
DATE: \_\_\_\_\_

CHECKED: \_\_\_\_\_  
DATE: \_\_\_\_\_

**Design Criteria - Input**

**General Design Criteria**

Peak Delivered Water Flow = 2400 gpm  
Feed Nitrate Concentration = 15 mg/L  
Target Delivered Water Nitrate Concentration = 0 mg/L  
Feed Water Dissolved Oxygen = 5 mg/L  
Average Water Temperature = 20 °C  
Upstream Pressure Head = 92 ft  
Required Downstream Pressure Head = 46 ft  
FWW Discharge Static Head = 20 ft

Select Redundancy Basis: ☐ Total System Redundancy  
☒ % Redundancy per Tank (Minimum)

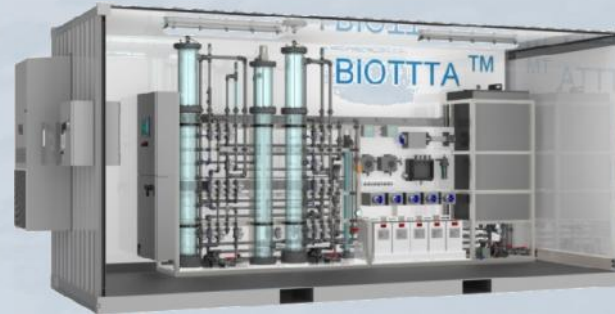
Target % Redundancy = \_\_\_\_\_  
Minimum % Recovery = \_\_\_\_\_

**Filter Design**

Biofilter GAC Bed Depth,  $l$  = 60 in  
Biofilter Effective Medium Size,  $d_e$  = 1.2 mm  
Polishing Filter GAC Bed Depth,  $l$  = 48 in  
Polishing Filter GAC Effective Size,  $d_e$  = 1 mm  
Polishing Filter Sand Bed Depth,  $l$  = 12 in

1. Equipment cost = \$193,000
1. Installed cost =  $1.5 \times \text{equipment cost} = \$290,000$
1. Annual O&M (chemicals + power) = \$8,800





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